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TRANSLATION OF EUROPEAN PATENT (UK) UNDER SECTION 77 (6) (a)

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<u>PATENTS ACT, 1977</u>

IN THE MATTER OF
European Patent No. 95 107 863.3
Application No. 0 744 527
in the name of
BAKER HUGHES INC.

I, DENNIS STANLEY TAVENER, Fellow of the Institute of Linguists and Member of the Institute of Translation and Interpreting, of 52 Garden Wood Road, East Grinstead, West Sussex RH19 1JU, hereby certify that I am the translator of the attached document and that it is a true translation to the best of my knowledge and belief of the above-mentioned European Patent.

Signed this 26th day of June 2001

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(Dennis S. Tavener, FIL., MITI)

The invention relates to a method of and an apparatus for transmitting data available at the surface to a data receiver disposed below ground in a bore hole, in accordance with the preamble to claims 1 to 7.

US-A-4 471 843 discloses such a method and such an apparatus and is deemed to be the nearest prior art.

In the case of a further known method of this type (US-A-5 332 048), the volumetric flow of circulating medium generated by the drilling and circulating pump is altered by sequential switching of the pump on and off. The sensor is thereby constructed as a flow switch which informs the data receiver of the on/off status of the flow of circulating medium, said data receiver then further processing the switching signals while taking into account their time-related sequence. Data transmitted and processed in this way can then trigger appropriate consequences, for example the presetting of an altered drilling direction for a directional drilling tool.

The successive switching of the drilling mud pump or pumps on and off again exposes them to considerable strain while they are in operation and the result is considerable wear and tear. At the same time however the drilling operation is adversely affected by the interruption in the drilling process while data is being transmitted, which can reduce drilling progress and the effective life of the drill head regardless of whatever special construction this may be. This applies particularly to data transmission procedures which take a considerable time on account of the quantity of data to be transmitted.

The invention is concerned with the problem of suffering minimal adverse effect on drilling operations due to the transmission of data to an underground data receiver carried out by simple means which operate substantially without wear and tear.

The invention resolves the problem by a method having the characterising features set out in claim 1 and by an apparatus having the characterising features set out in claim 7. With regard to further essential developments, reference is made to claims 2 to 4 and 8 to 16.

The method and apparatus according to the invention leave the drilling mud pump or pumps in an unchanged operating mode while data is being transmitted so that they constantly work under optimum conditions. The influencing of the constant volumetric flow generated by the drilling mud pump and independently of the pump operation makes it possible to alter volumetric flow in a pulsed fashion which is independent of the start-up and shut-down characteristics of the pump(s) and which only has to take transmission-technical parameters into account. Since during periods of data transmission circulating medium circulates in a constant and only fluctuating volumetric flow, adequate removal of drilling fines from the cutting area of the drill head and cooling of its cutting members can be guaranteed so that the drilling operation can be continued even over relatively long periods of time for data transmission with adverse effects. Since the frequency, the amplitude and flank pattern of the altering pulses of the volumetric flow of the circulating medium can be chosen substantially freely and linked to one another, reliable transmission of data can be guaranteed even if, while data is being transmitted to an underground data receiver in accordance with the invention, data is being simultaneously transmitted from an underground data store to an above-ground data receiver.

The structure means required are confined to a simple controlled branch pipe which can be operated with virtually no wear and tear, and to a volumetric flow meter which can likewise be produced at minimal structural cost. Constructing the volumetric flow meter as a turbine which is subject to the flow of circulating medium in the drill line, with a measured value transmitter in the form of a generator driven by the turbine, permits of particularly precise acquisition of variations in volumetric flow while at the same time the complication and costs are minimised since the turbine with the generator can at the same time be used as an underground voltage source to operate electrical and/or electronic consumer devices.

Further details and advantages of the invention will emerge from the ensuing description of an embodiment of the object of the invention which is shown in greater detail in the attached drawings, in which:

Fig.1 is a diagrammatic overall view of a drilling plant with various partial zones;

Fig.2 is a details view of a modified embodiment of the means of controlling the shut-off valve in the branch pipe;

Fig.3 is a broken away partial section through the drilling tool in the region of the data receiver;

Fig.4 illustrates the pulse-like pattern of a variation in volumetric flow according to the invention, during the transmission of signals;

Fig.5 is a modified configuration of the pulse pattern, and

Fig.6 is a diagram illustrating the winding voltage of the generator in relation to time.

Fig. 1 illustrates a drilling plant for drilling in underground formations with a drill tower 1 for constructing and driving a drill line 2 which has a swivel head 3 at its top end 3 and a drilling tool 4 at its bottom end. The drilling tool disposed in the bore hole 5 comprises a housing 6, stabilisers 7, 8 and a portion 9 with stabiliser ribs 10 which can be extended and retracted in a controlled fashion. The portion 9 is mounted on and is adapted to rotate about the tool spindle 11 and in relation to the housing 6 while in operation it is rotationally rigid in the bore hole 2 whereas the drilling tool 4, together with the drill head 12, for example a rotary drill bit or roller bit, can be caused to rotate by means of the drill line 1.

Furthermore, the drilling installation comprises an only diagrammatically shown drilling mud tank 13 in which there is a supply of circulating medium 14, one (or a plurality of parallel or series-connected) drilling mud pump(s) 15, of which the inlet connector(s) 15' extend(s) into the supply of circulating medium, a main pipe 16 which connects the drilling mud pump 15 to the swivel head 3, and a return pipe 17 which is connected to a header 18 at the top of the bore hole 5 and which discharges into the drilling mud tank 13. Through the return pipe 17, circulating medium is transferred to the drilling mud tank 13 from the annular space 19 between the wall of the bore hole and the drill line 2.

In operation, the drilling mud pump 15 delivers circulating medium 14 in a circuit in the direction of the arrow 20 from the drilling mud tank 13 downwards through the interior of the drill line 2 and drill head 12 and subsequently in the direction of the arrow 21 upwards through the annular space 19 between the drill line 2 and the bore hole wall and onwards to the drilling mud tank 13. The drilling mud pump 15 is driven by a diagrammatically shown drive motor 22 of constant output and accordingly delivers circulating medium 14 in a constant volumetric flow to the main pipe 16.

Connected to the main pipe 16 and discharging into the drilling mud tank 13 is a branch pipe 23 into which a shut-off valve 24 which can be actuated by hand or by any suitable drive means 25 is incorporated. The drive 25 can be controlled by an electronic control and monitoring device (not shown in Fig. 1), by means of which sequential changes in volumetric flow can be effected automatically, as will be dealt with hereinafter. By means of the shut-off valve 24, the branch pipe 23 can be completely isolated or made completely available for the through flow of a partial flow of circulating medium, the direction of flow of which is illustrated by the arrow 26. Downstream of the shut-off valve 24 there is a throttle 27 by which the maximum amount of volumetric flow change brought about by opening the branch pipe 23 can be predicted, which enters that part of the main pipe 16 which is situated after the branching point and therefore enters the circulating medium circuit.

In the case of the embodiment of shut-off valve 24' according to Fig. 2, the shut-off member 28 is actuated by a pressurised medium drive 29 subject to the action of a control valve 30 which applies a pressurised medium to it, for example compressed air from a pressurised medium storage means 31. The control valve is connected by pressurised medium lines 32, 33 to the pressurised medium store 31, there being incorporated into the pressurised medium line 33 a switching valve 34 controlled for example by an electronic control and monitoring unit 35 which preferably consists of or comprises an electronic computer. By means of the regulating valve 30, it is possible to regulate the speed at

which the shut-off member 28 opens and closes. At the same time, it is possible to move to intermediate positions between the opened and closed positions of the shut-off member 28.

The preferred variation in volumetric flow which is illustrated is carried out above ground but in principle, the variation can be made anywhere downstream of the pump(s) which is situated upstream of the underground sensor which detects the variation in volumetric flow.

In the case of the example of embodiment illustrated, there is in the housing 6 of the drilling tool 4 and subject to the action of the flow of circulating medium in the drill line 2, a turbine 36, the guide wheel 37 of which is rigidly connected to the housing 6 and the rotor 38 of which is supported by bearings 40, 41 on a central supporting member 39 fixed in the housing 6 by a stator carrying and centring part 39, so that the rotating blade ring 42 is able to rotate in the direction of the arrow 43. At the same time, the turbine rotor 38 forms the rotor housing of a generator which carries magnets 44 and encloses a winding package 45 mounted on the supporting member 39. The output voltage is applied via an electrical connecting line 46 to an electronic processing unit indicated diagrammatically at 47 and which is at the same time the data receiver and which may for example be part of an electronic device for controlling the directional drilling tool 4.

In order to carry out a process of data transmission in respect of data available at the surface to the underground data receiver 47, during uninterrupted drilling operations, the shut-off valve 24, 24' is actuated in such a way as to open the branch pipe 23 so that in the flow of circulating medium in the drill line 2 and also in the region of the turbine 36, there is a reduction in volumetric flow which results in a reduction in the rotary speed of the rotor 38 of the turbine 36. This variation in rotary speed which is proportional to the variation in volumetric flow is detected by the data receiver 47 as a signal which counts for example the number of passages through zero in relation to time of the winding voltage curve 48 shown in Fig. 6. In Fig. 6, the winding voltage is associated with the

ordinate 49 while the time is associated with the abscissa 50 of the co-ordinates; intersection and the time period 51 corresponds to one complete rotation of the turbine/generator rotor 38.

Closing the shut-off valve 24, 24' increases the volumetric flow of circulating medium 14 in the region of the turbine 36, with the result that the increase is understood by the data receiver 47 to be a further processable signal.

Instead of the preferred turbine/generator combination which in many applications is in any case required for supplying underground consumer devices, it is also possible to use any other suitable volumetric flow meter. Also, instead of a generator, it is possible to associate with the turbine any other rotary speed sensor, for example sensors which operate on the centrifugal force or punched disc principle.

According to the manner of actuation and the design of the shut-off valve, so a pulse-like pattern can be imposed on the variations in volumetric flow, as illustrated for example by the trace 52 in Fig. 4, illustrating the variation in volumetric flow in relation to time.

The pattern or steepness of the pulse flanks 53 depends thereby upon the way in and speed at which the shut-off member of the shut-off valves 24, 24' is actuated. In accordance with the variations in volumetric flow, so also the generator voltage changes, as can be seen from Fig. 5, in which by way of example the generator voltage is plotted in relation to time.

In order to vary the pulse pattern, the time span between commencement and completion of a partial flow branch-off, the proportion of branched-off partial flow in relation to the total flow of circulating medium delivered by the circulating mud pump 15 and/or the time-related pattern of commencement and/or completion of the branching-off of circulating medium can be varied. Preferably, the variations in volumetric flow are illustrated by signals coded as a digital sequence and which are adapted to trigger any

desired consequential actions.

Data transmission is independent of the type of data which is to be transmitted. It is possible to transmit both control signals for a directional drilling tool, signals for switching over operating modes of individual components of the underground system, depth data, stop-and-start signals to an underground transmitter, etc., so that the transmission of data in accordance with the invention can find universal application. If the control device is constructed as an electronic computer, it is also possible to perform automatic data exchange operations on the lines of an automatic reaction to the data received in the data content.

Patent claims

1. A method of transmitting data present at the surface to a data rèceiver disposed underground in a bore hole, in particular a receiver unit in a drilling implement, during drilling operations, and in which at least one surface-moulded drilling mud pump pumps a circulating medium around in a circuit from a drilling mud tank downwards through the interior of a drill line and a drill head and upwards in the annular space between drill line and bore hole wall and on to the drilling mud tank, the volumetric flow of circulating medium being altered in order to transmit data and the alteration being detected and evaluated by the data receiver, characterised in that the volumetric flow of circulating medium generated by the drilling mud pump is altered n a zone situated downstream of the said pump.

2. A method according to claim 1, characterised in that the volumetric flow is altered by branching a partial flow from the volumetric flow of circulating medium which is generated by the drilling mud pump.

3. A method according to claim 2, characterised in that the branched-off partial flow is fed back to the drilling mud tank.

4. A method according to one of claims 1 to 3, characterised in that the length of time between the start and finish of a partial flow being branched off is varied.

5. A method according to one of claims 1 to 4, characterised in that the branched-off partial flow is varied in its proportion of the total flow of circulating medium which is delivered by the drilling mud pump.

6. A method according to one of claims 1 to 5, characterised in that at the start and/or at the end of a branching-off process the proportion of the total flow of circulating medium which is represented by the branched-off partial flow is increased from zero to

maximum or is reduced from maximum to zero, in either case steplessly or in several stages.

7. An apparatus for transmitting data available on the surface to a data receiver (47), particularly a receiver unit in a drilling tool (3) disposed underground in a bore hole, during drilling operations, with a drilling mud tank (13), at least one drilling mud pump (15), a main pipe (16) connected to the drilling mud pump (15) and leading to the top end of the drill line (2) and a sensor associated with the data receiver and responding to variations in the volumetric flow in the drill line (2), characterised in that a branch pipe (23) controlled by a shut-off vale (24, 24') is connected to the main pipe (16), and a volumetric flow meter (36, 38, 44, 45) is provided as sensor.

8. An apparatus according to claim 7, characterised in that the volumetric flow meter provided is a turbine (36) disposed in the housing (6) of the drilling tool and subject to the flow of circulating medium in the drill line (2) and of which the rotor (38) is coupled to a measured value transmitter which detects the rotary speed of said rotor.

9. An apparatus according to claim 7, characterised in that the measured value transmitter provided is a generator (44, 45) driven by the rotor (38) of the turbine (36) and the output voltage of which is related to the volumetric flow.

10. An apparatus according to one of claims 7 to 9, characterised in that the shut-off member (28) of the shut-off valve (24, 24') in the branch pipe (23) can be actuated by a drive (25, 29) adapted to be controlled by an electronic control device.

11. An apparatus according to claim 10, characterised in that the drive provided is a pressurised medium drive (29) subject to the action of a pressurised medium exerted by a control valve (30).

12. An apparatus according to claim 11, characterised in that the control valve (30)

is connected to a compressed air source (31) and in that a switching valve (34) is adapted to be actuated by an electronic control device (35) is disposed in a connecting line (33).

13. An apparatus according to one of claims 10 to 12, characterised in that an electronic computer is provided as the control device.

14. An apparatus according to one of claims 7 to 13, characterised in that a throttle (27) is disposed in the branch pipe (23) downstream of the shut-off valve (24, 24').

15. An apparatus according to one of claims 7 to 14, characterised in that the branch pipe (23) discharges into the drilling mud tank (13).

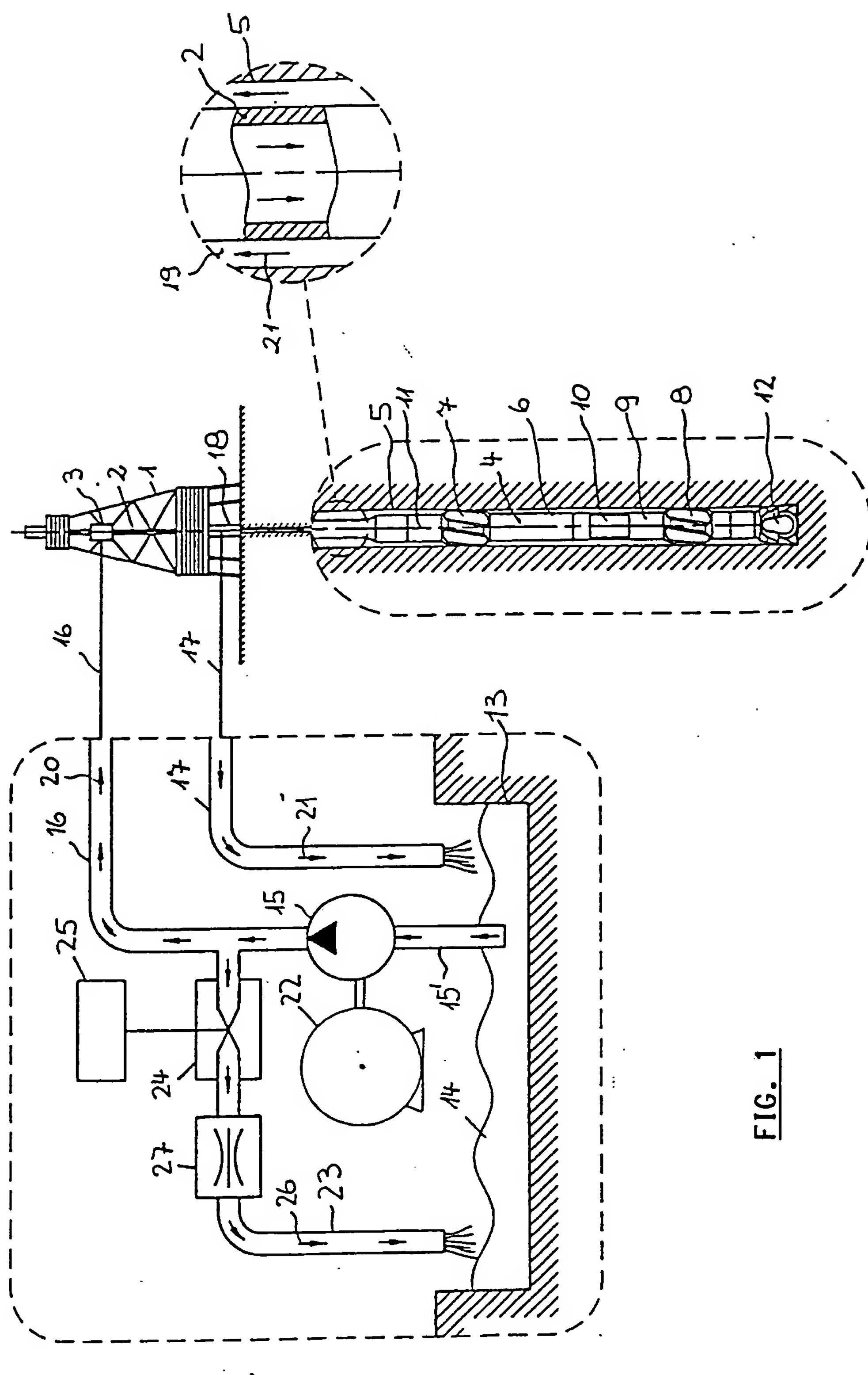
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FIG. 1

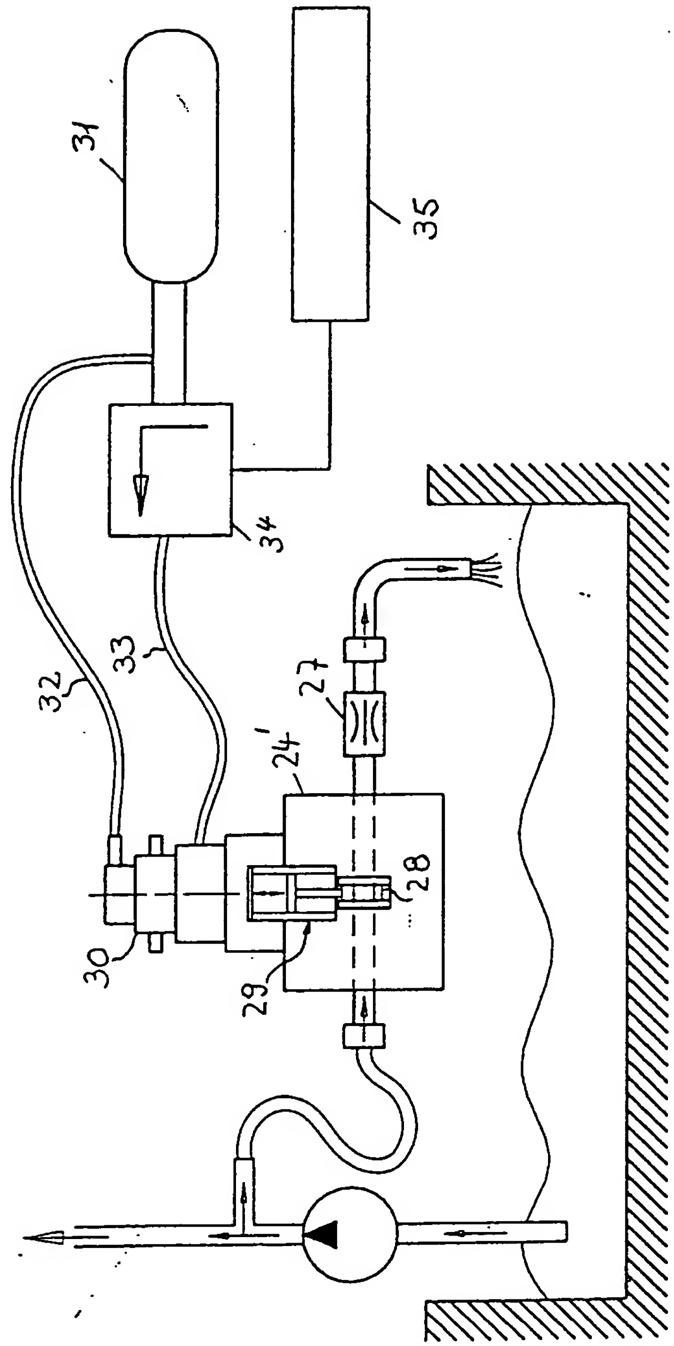

FIG. 2

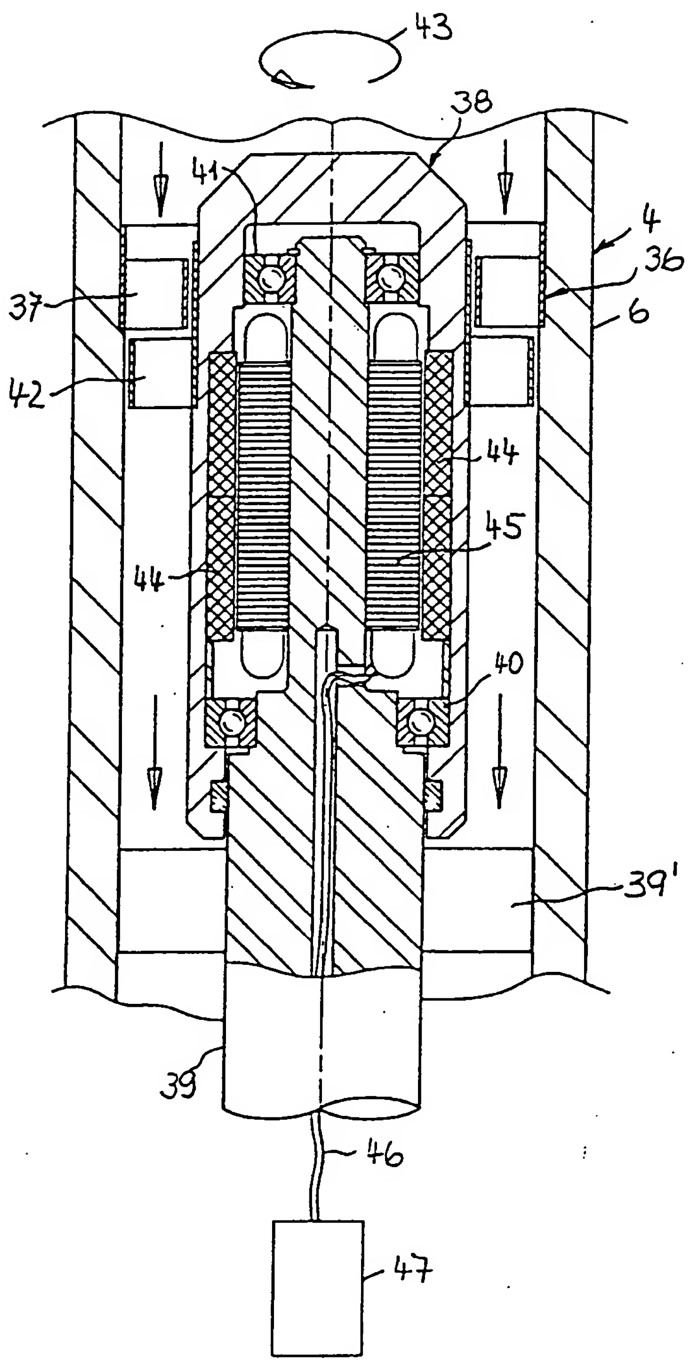

FIG. 3

FIG. 4

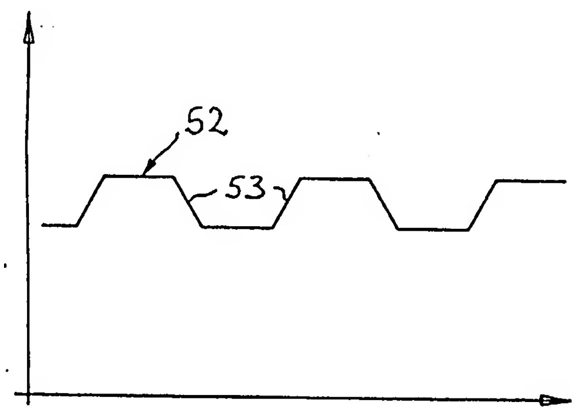

FIG. 5

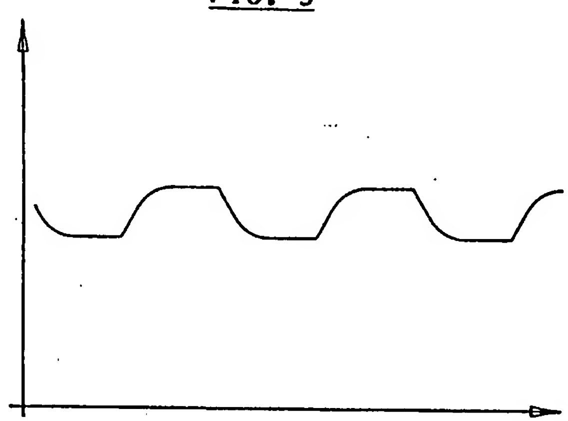

FIG. 6